Little Green Lies: Dissecting the Hype of Renewables

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US Army Corps of Engineers
BUILDING STRONG®

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Renewable Power Roadmap

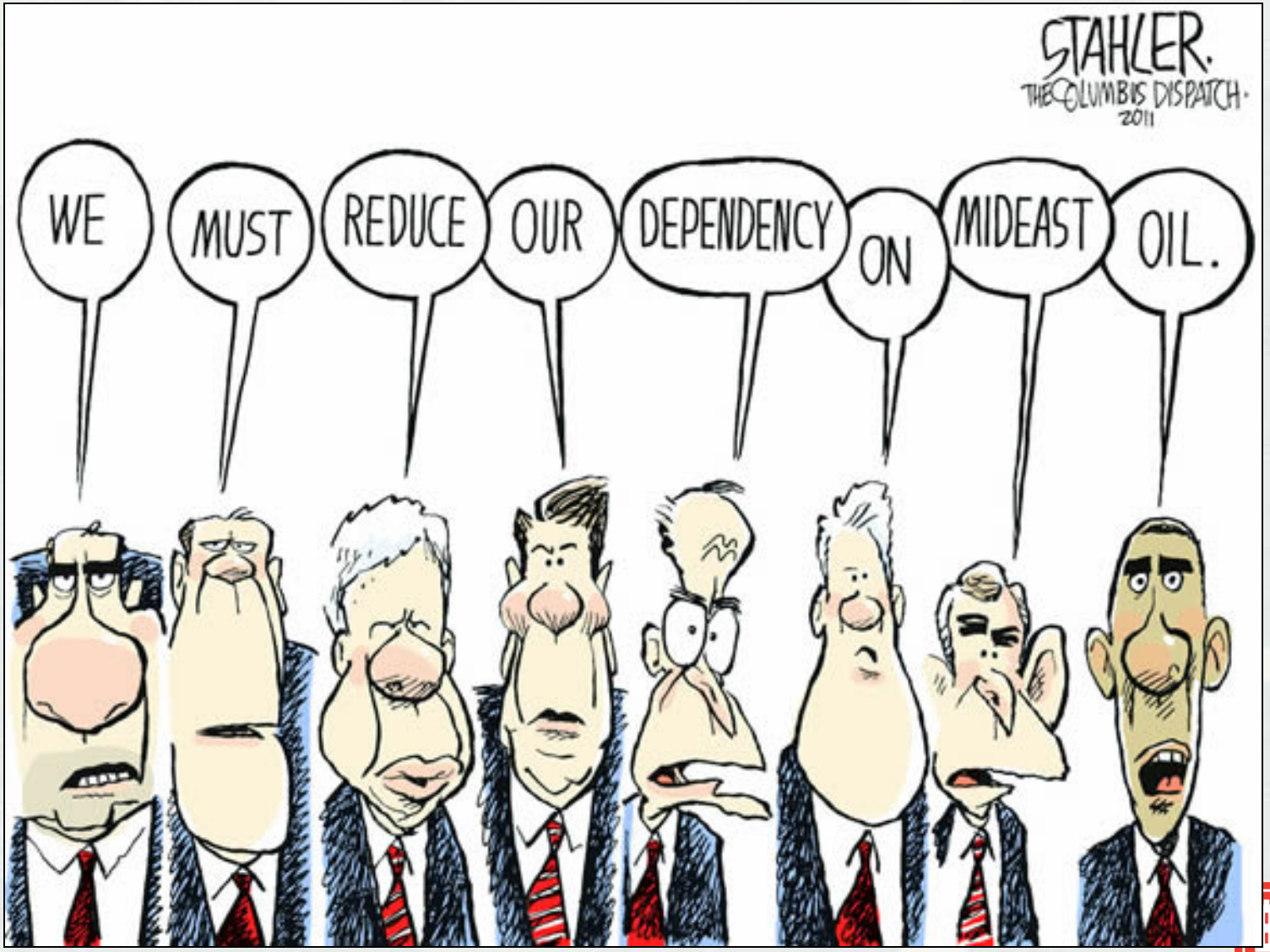
The most difficult subjects can be explained to the most slow-witted man if he has not formed any idea of them already; but the simplest thing cannot be made clear to the most intelligent man if he is firmly persuaded that he knows already, without a shadow of doubt, what is laid before him.

-- Leo Tolstoy

"Once people store their factual inferences in memory, these inferences are indistinguishable from hard data. The more they then use this stored information, the more central it becomes to future inferences and judgments...People constantly overrate the accuracy and reliability of their beliefs.“

--University of Illinois study, James Kuklinksi, et al, “Misinformation and the Currency of Democratic Citizenship", 2000:

This Time We Mean it



Why Bother?

What's all the fuss about?

Oil Reserves:

- **World 1,475 bbls, 50 years (R/P ratio)**
- **US: 28.5 bbls 18 years (R/P ratio)**

Coal Reserves:

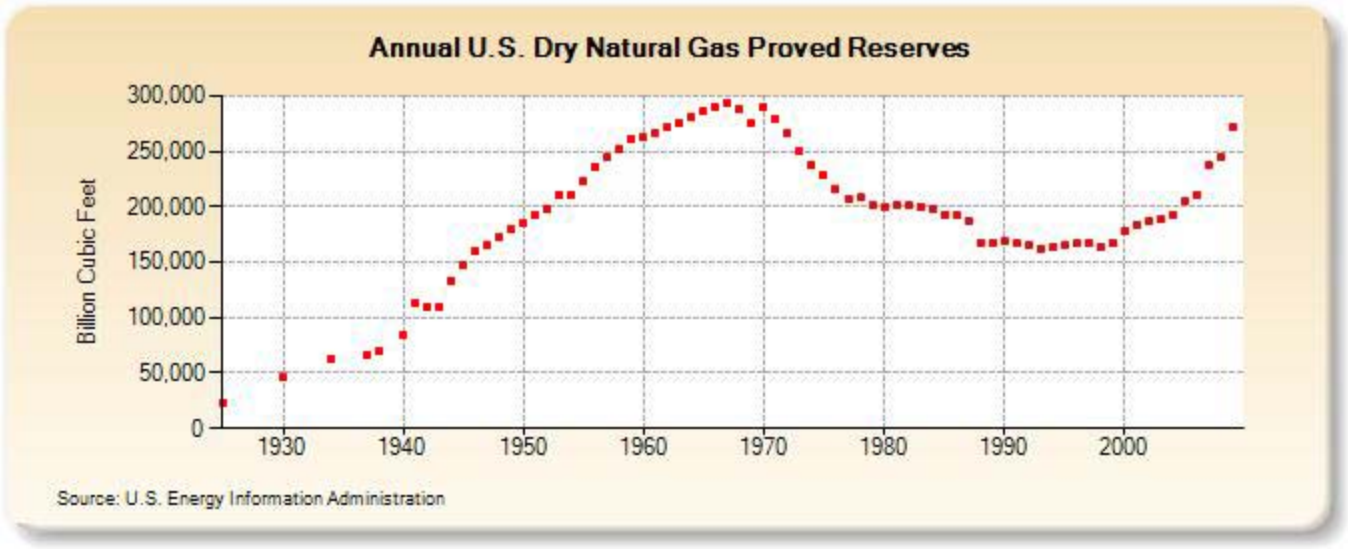
- **World 826 billion tons, 119 years (R/P)**
- **US: 238 billion tons 245 years (R/P)**

Natural Gas Reserves*:

- **World: 9,270 TCF (187.5TCM), 87.9 years (R/P)**
- **US Reserves (Including Unproved): 2,587TCF, 124 years (R/P)**

Source: 2010 BP Statistical Energy Review (Except *EIA Annual Energy Outlook, 2010)
*2011 EIA Update

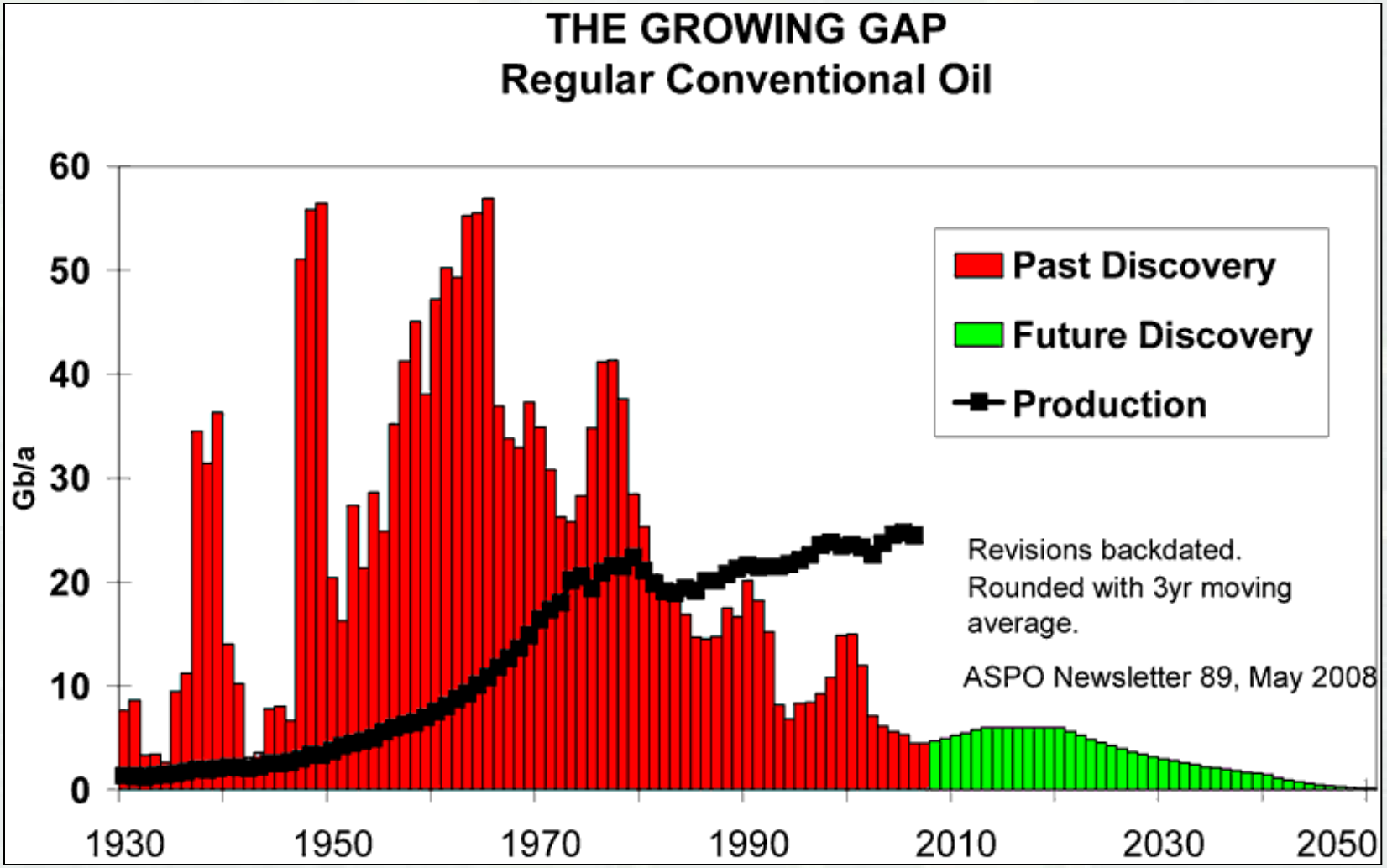
Why Bother?



1990 Global Proved Oil Reserves: 1T Bbls
2010 Global Proved Oil Reserves: 1.5T Bbls

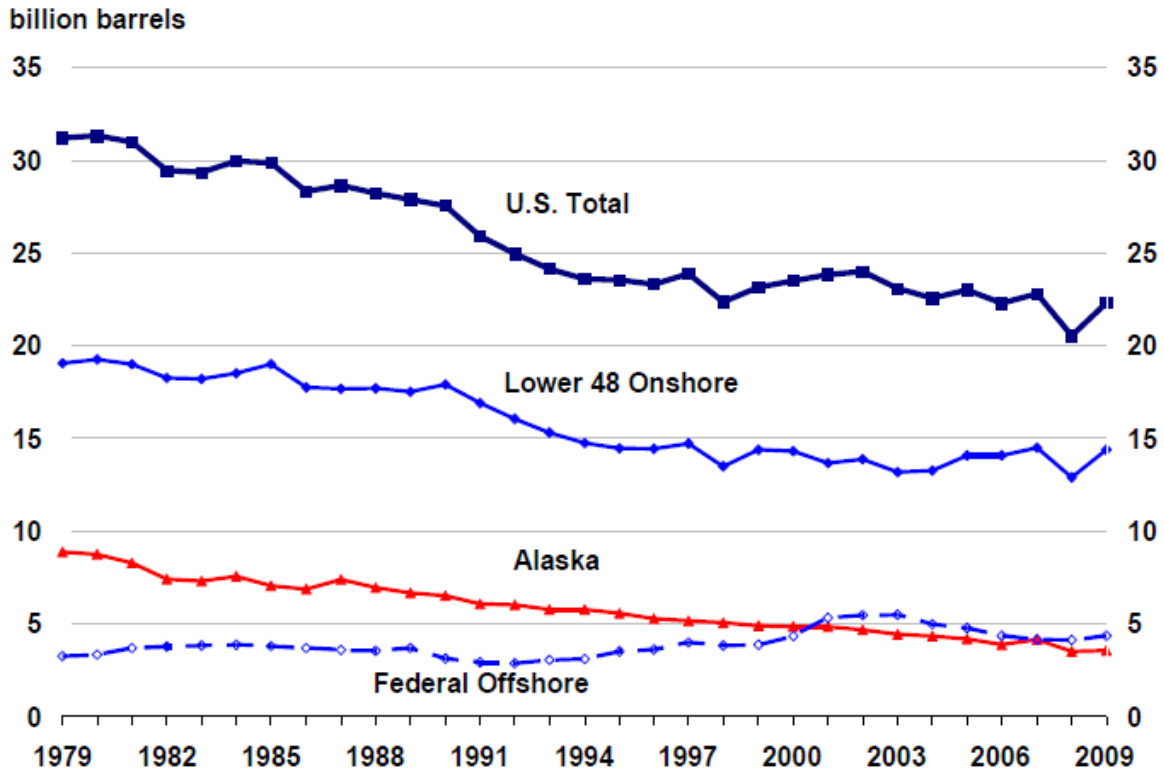
Oil Produced, 1990-2010: ~.5T Bbls

Why Bother?


THE GROWING GAP
Regular Conventional Oil
Gb/a
60
50
40
30
20
10
0
1930
1950
1970
1990
2010
2030
2050
Past Discovery
Future Discovery
Production
Revisions backdated.
Rounded with 3yr moving average.
ASPO Newsletter 89, May 2008

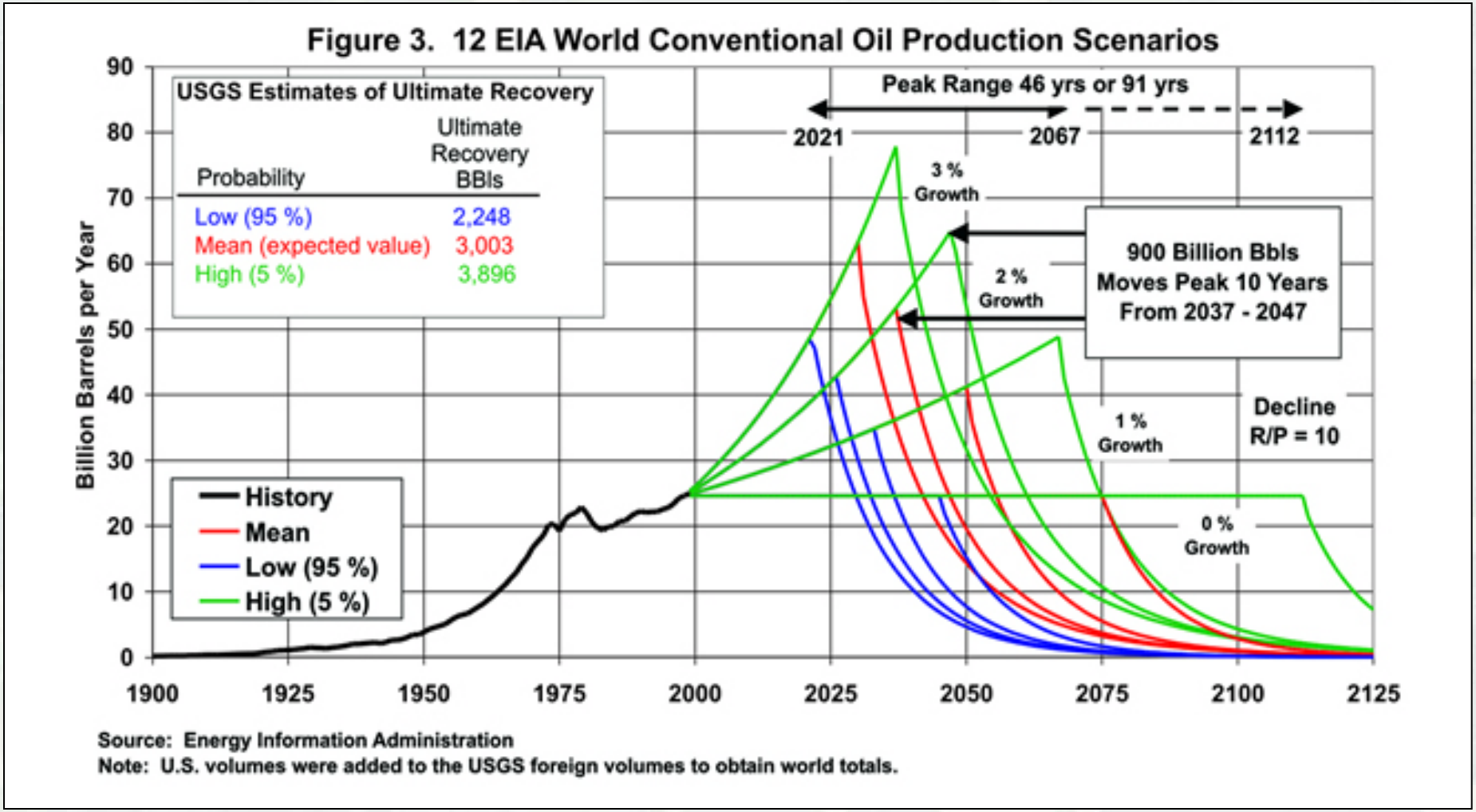
Affordable Renewable Energy Strategies

Figure 7. U.S. Crude Oil plus Condensate Proved Reserves, 1979-2009



Source: U.S. Energy Information Administration

Affordable Renewable Energy Strategies



Population Trends

Figures in Millions	2010	2030	2050	% Increase
World	6,853	8,259	9,284	36%
Less Developed Countries	5,621	6,984	8,005	42%
More Developed Countries	1,231	1,275	1,279	4%
USA	307	373	439	43%
India	1,173	1,460	1,656	41%
Pakistan	184	243	290	58%
China	1,330	1,391	1,303	-2%
Russia	142	124	109	-23%
Japan	126	113	93	-26%
Eastern Europe	119	112	99	-17%
Sub Saharan Africa	850	1,320	1,889	122%
Northern Africa	164	212	248	51%
Nigeria	155	212	264	70%
Ethiopia	88	162	278	216%
Congo	75	131	198	164%

Source: US Census Bureau, Population Division

Energy Trends

	Per Capita Energy Use (Kg Oil Equivalent)
World	1,819
USA	7,766
Russia	4,730
France	4,258
Germany	4,027
Japan	4,019
UK	3,464
China	1,484
Brazil	1,239
Indonesia	849
Nigeria	722
India	529
Pakistan	512
Ethiopia	290
Congo	289
Bangladesh	163

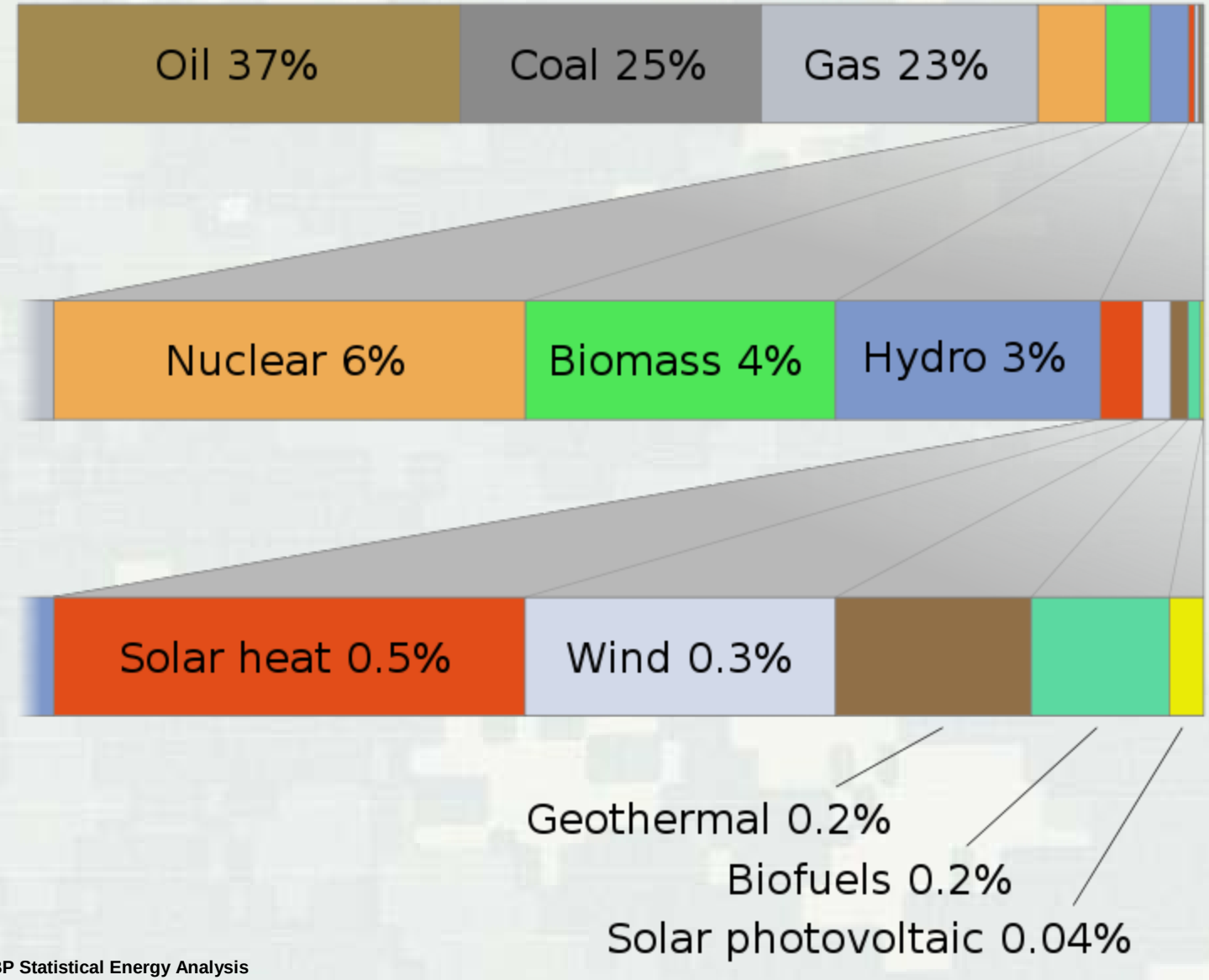
2010 Per Capita Energy Estimate:
1,819 * 6.7B people = 12,187B KG Oil Equivalent

2050 Per Capita Energy Forecast (1% Annual Growth):
2,708 * 9.3B people = 25,184B KG Oil Equivalent

2050 Per Capita Energy Forecast (2% Annual Growth):
4,016 * 9.3B people = 37,348B KG Oil Equivalent

Sources: 2009 BP Statistical Energy Analysis, US Energy Information Administration

Energy Trends



Sources: 2006 BP Statistical Energy Analysis

Three-Pronged Solution

System and Building Efficiencies

Demand Reduction & Flattening

Generation and Distribution

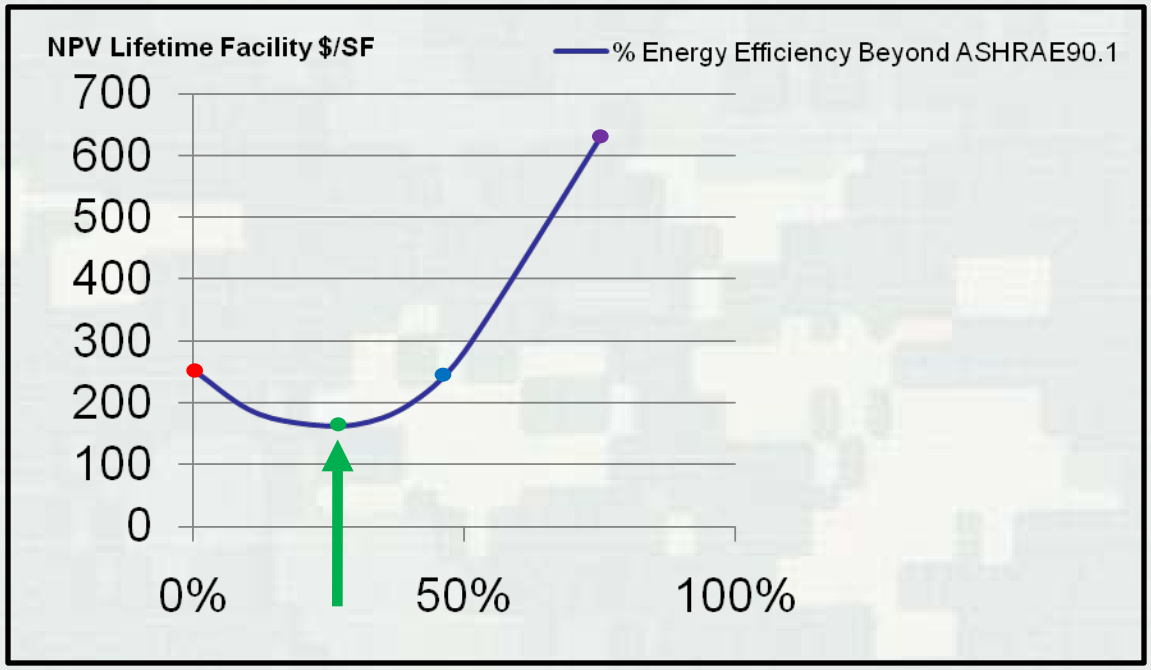
Three-Pronged Solution

1) System and Building Efficiencies
   - A) Current ASHRAE & LEED Minimums
     - i. Occupancy Sensors/Timers
     - ii. Space lighting/heating/cooling properties
     - iii. Window, Roof, Envelope properties
   - B) Federal Improvement Mandates (EPAct/EISA/EOs)
     - i. EPAct05 / EISA07
     - ii. Executive Orders 13423, 13514
     - iii. Federal Energy Management Program (FEMP)
     - iv. Energy Star Program
   - C) Private Efforts
     - i. Utility Rebates (appliances, PV arrays)
     - ii. Dynamic Pricing

Baseline Energy Efficient Building

Present Design (~30% - 40% Beyond ASHREA90.1-2007), Point 2

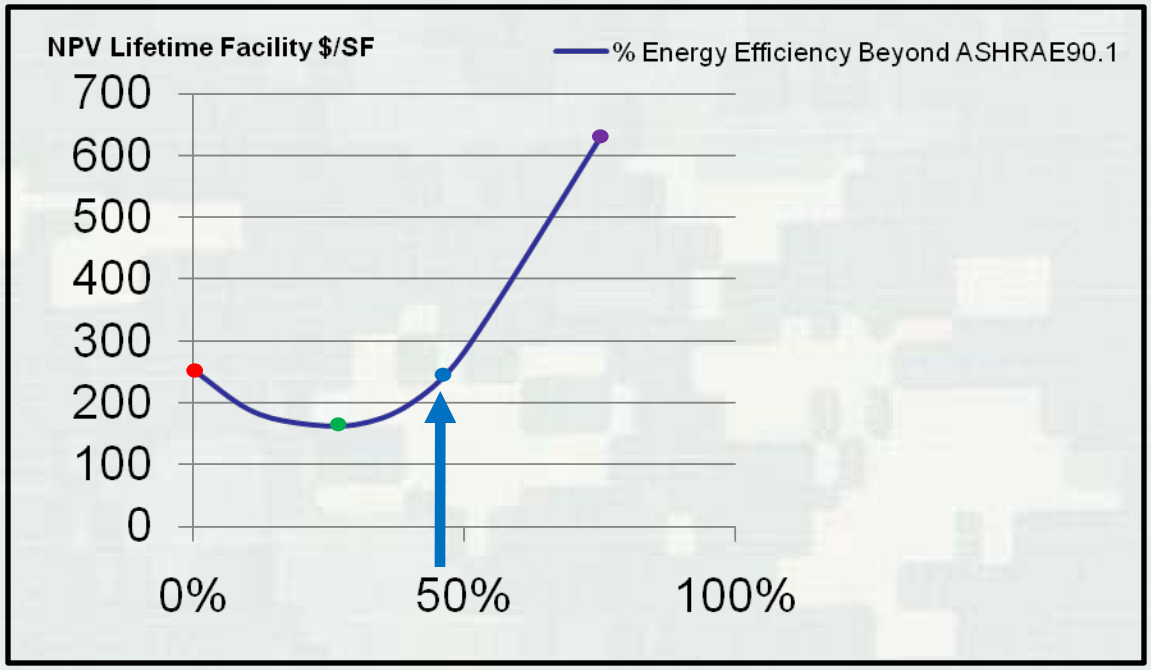
- Improved Envelope
- Increased Insulation
- Condensing Boilers
- HE Hot Water Heaters
- Proper Building Orientation
- Double-Pane Windows
- VFD Pumps & Fans
- Cool Roofs
- Low Flow Fixtures
- ERV / Enthalpy Wheels
- FEMP / Energy Star
- Decreased Lighting Intensities



More Energy Efficient Building

LCCA Neutral (~40% - 50% Beyond ASHREA90.1-2007), Point 3

- Triple Paned Windows
- Increased Insulation
- GSHP / WSHP
- Awnings/Overhangs/Shading
- Central Plants
- SIPs/EFIS/Styrofoam
- Daylighting & Photodimmers
- Air Conditioned Attics
- Radiant Heating
- Water Pre-Heat (Solar/Rejected)
- Floor Plan Changes: Lighting, Ventilation, Roof Types

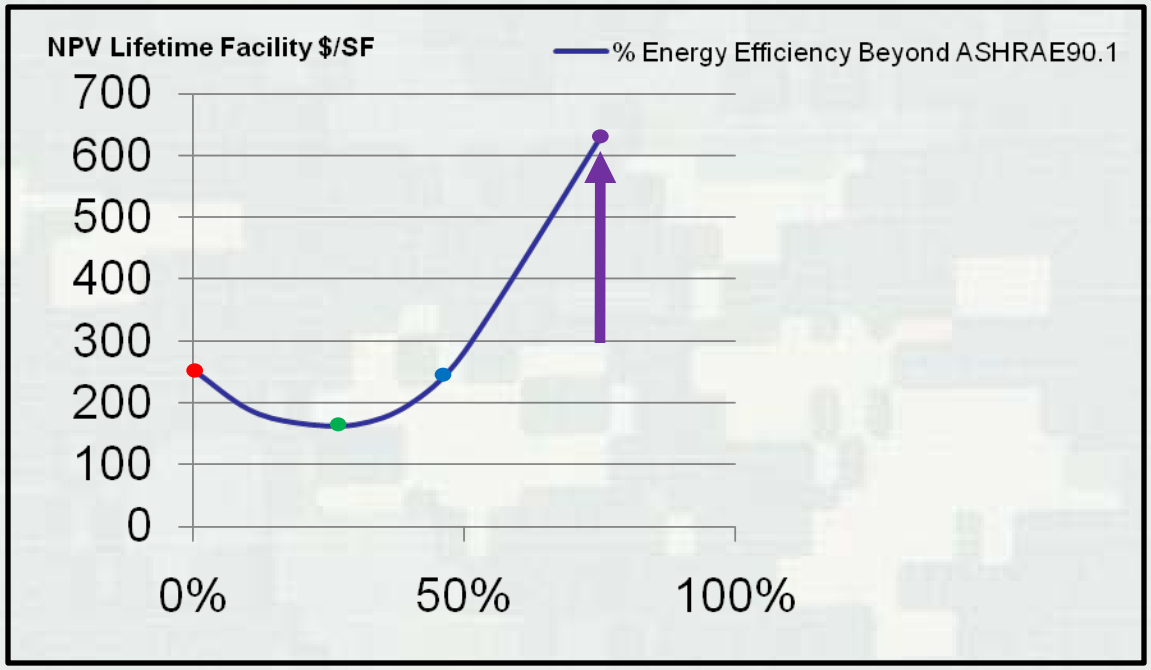


Most Energy Efficient Building

(~55+% Beyond ASHREA90.1-2007), Point 4

LCCA Negative but $$ < Generation

- Solid State (LED) Lighting
- Superior Envelope, R-30+
- Passive / Evaporative Cool
- Night Purging
- Variable Refrigerant Volume
- Complete Building Automation
- Wastewater Heat Recovery
- Building Mass / Labyrinths
- Thermal Energy Storage*
- Trombe Walls



*Doesn't necessarily reduce energy demand, but reduces peak – thus reducing support or generation plant required.

Federal & Department of Army Energy Efficiency

NREL Research Facility
Golden, CO

- 222KSF
- EUI Goal: 32kBTU/ft^2*yr
- LEED Platinum
- $259/SF
- 800 Occupants

Federal & Department of Army Energy Efficiency

NREL Research Facility
Golden, CO

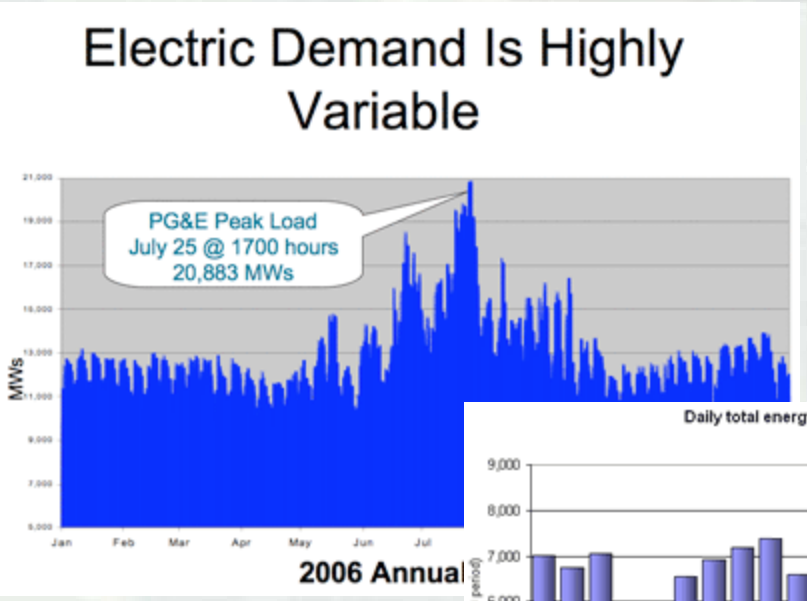
Cost Comparison:

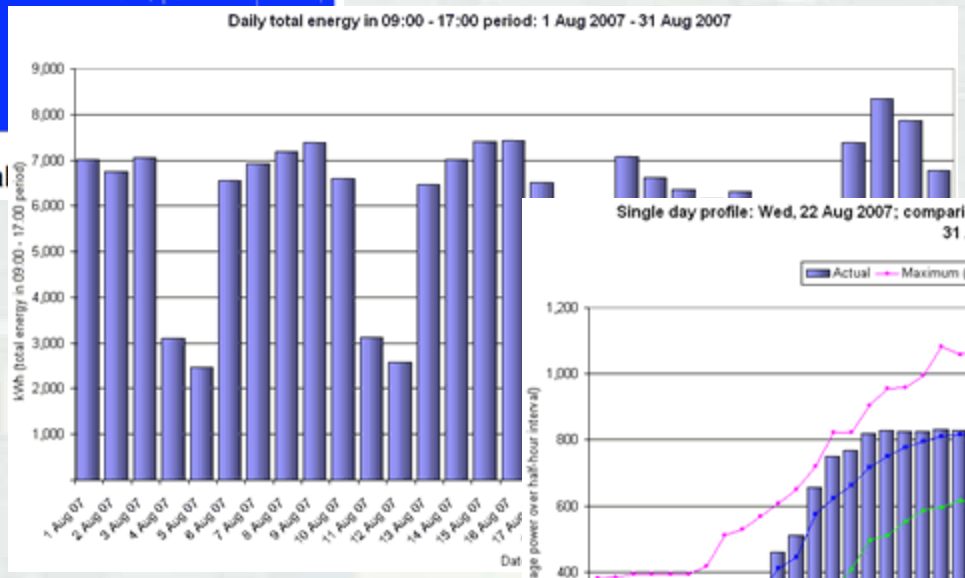
City Civic Center	90KSF	$310/SF	Silver
City Signature Ctr	186KSF	$247/SF	Platinum
Ft. Carson BDHQ	140KSF	$225/SF	Gold
NREL	222KSF	$259/SF	Platinum

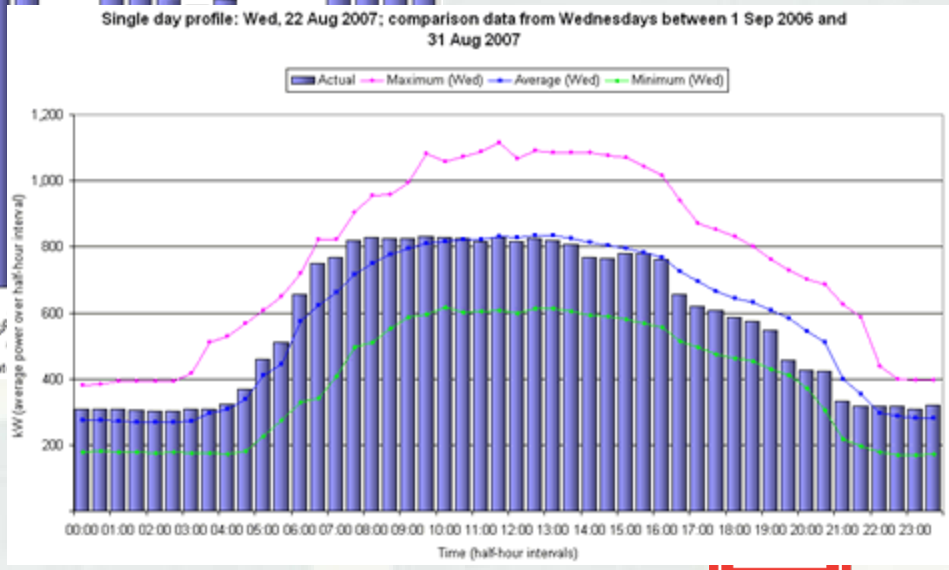
Three-Pronged Solution

2) Demand Reduction & Flattening
   - A) Dynamic Pricing (Smart Grids & Demand Response)
     - i. Tollway Minimum Speed Analogy
     - ii. Avoid Unintended Consequences
   - B) Cultural Shifts (Load Flattening)
     - i. Telecommuting
     - ii. Dynamic Tollway Pricing
   - C) Equipment Selection (Load Flattening)
     - i. Smart appliances
     - ii. Heat Pump applications
     - iii. TES

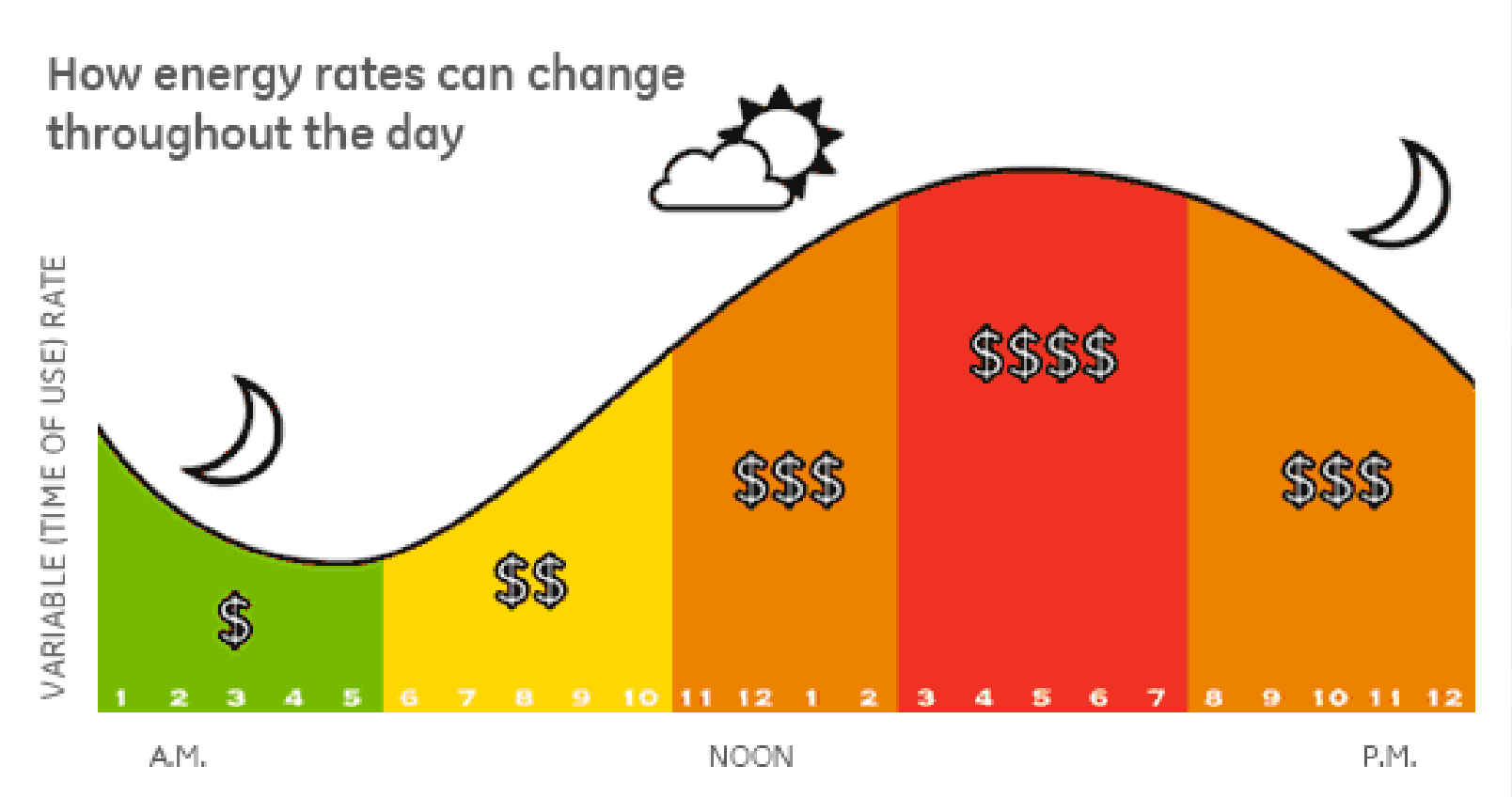
Three-Pronged Solution







Three-Pronged Solution



Three-Pronged Solution

So now we have:

1. Maximized the efficiencies within individual buildings & homes.
2. Aligned incentives for people to collectively maximize efficiencies and eschew waste and defer elective usages during peak times.
3. The last bit, barring living in a cold, dark box, requires power.

Three-Pronged Solution

3) Generation and Distribution
   - A) Greater Renewable Emphasis
     - i. PV
     - ii. CSP
     - iii. Geothermal
     - iv. Biomass
     - v. Wind
     - vi. Hydro
   - B) Nuclear
   - C) Natural Gas
   - D) Distributed Generation

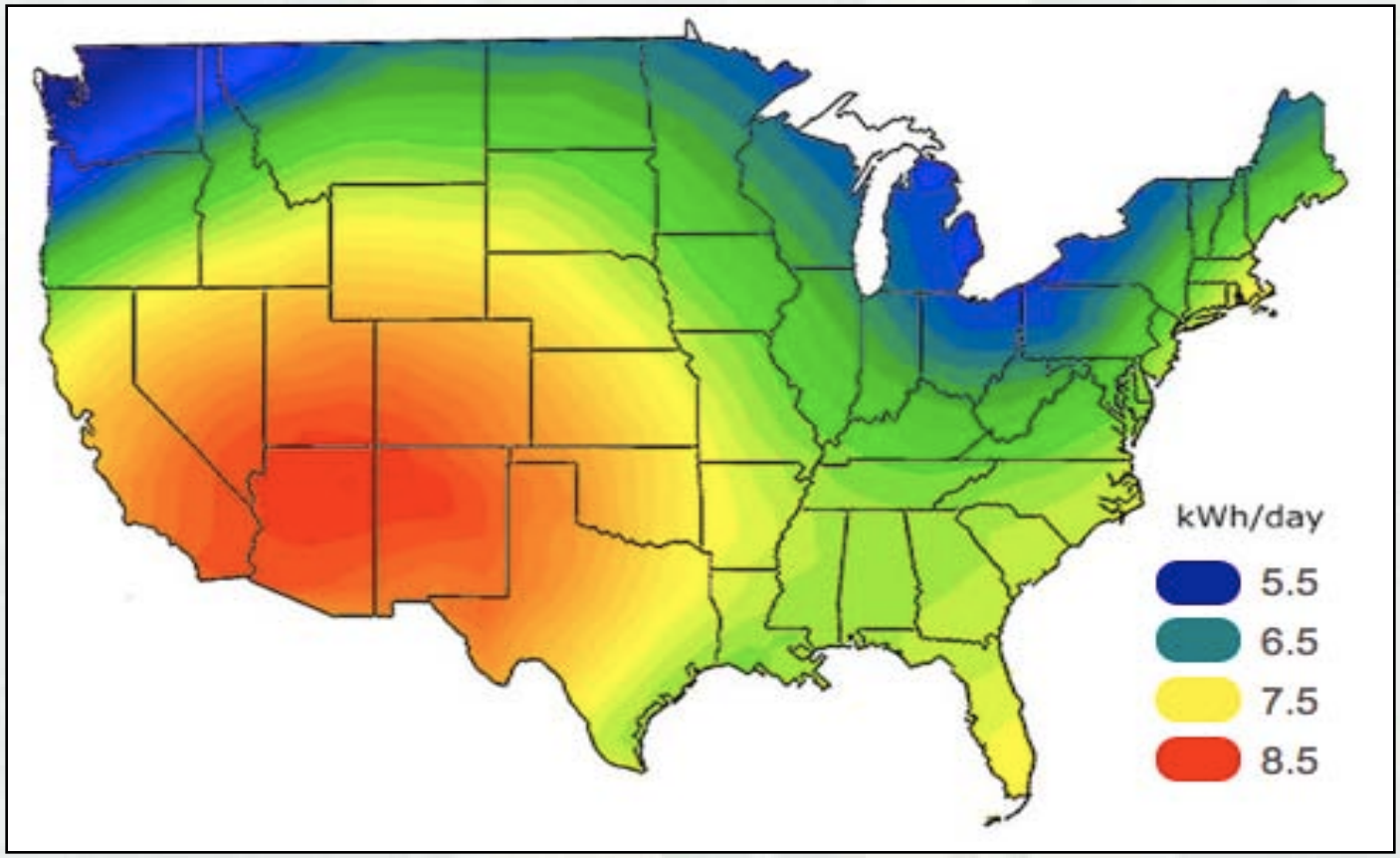
Federal CONUS Solar PV Arrays

Ft. Irwin, 500MW: $2B, ~$4/W, 14K Acres

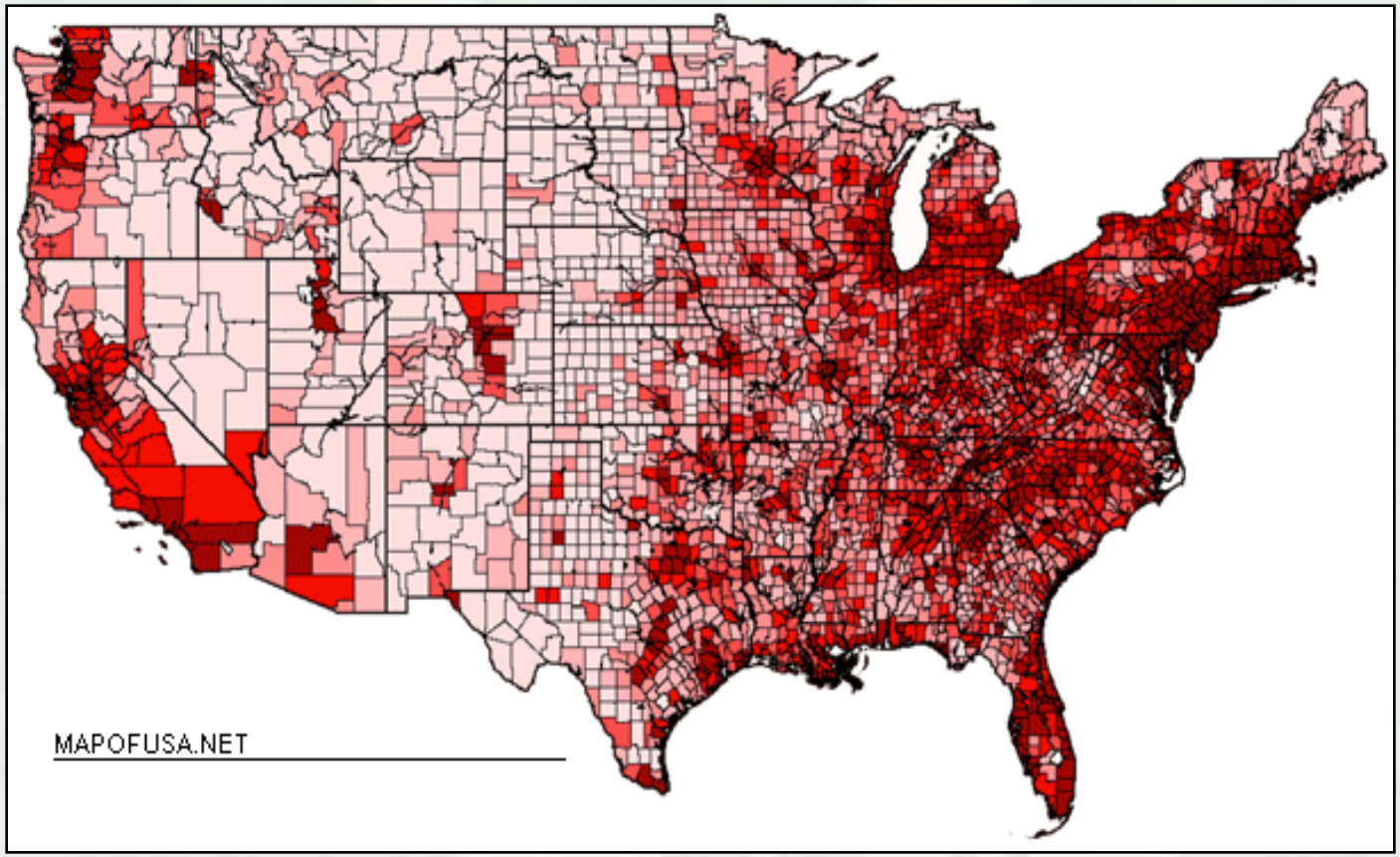
Ft. Nellis,14MW, $100M
(~$7/MW), 140 Acres
CF~24%

Ft. Carson, 2MW, $13M
(~$6.5/W), 15 Acres
CF~20%

USA Solar Resource (CSP / PV) Intensity



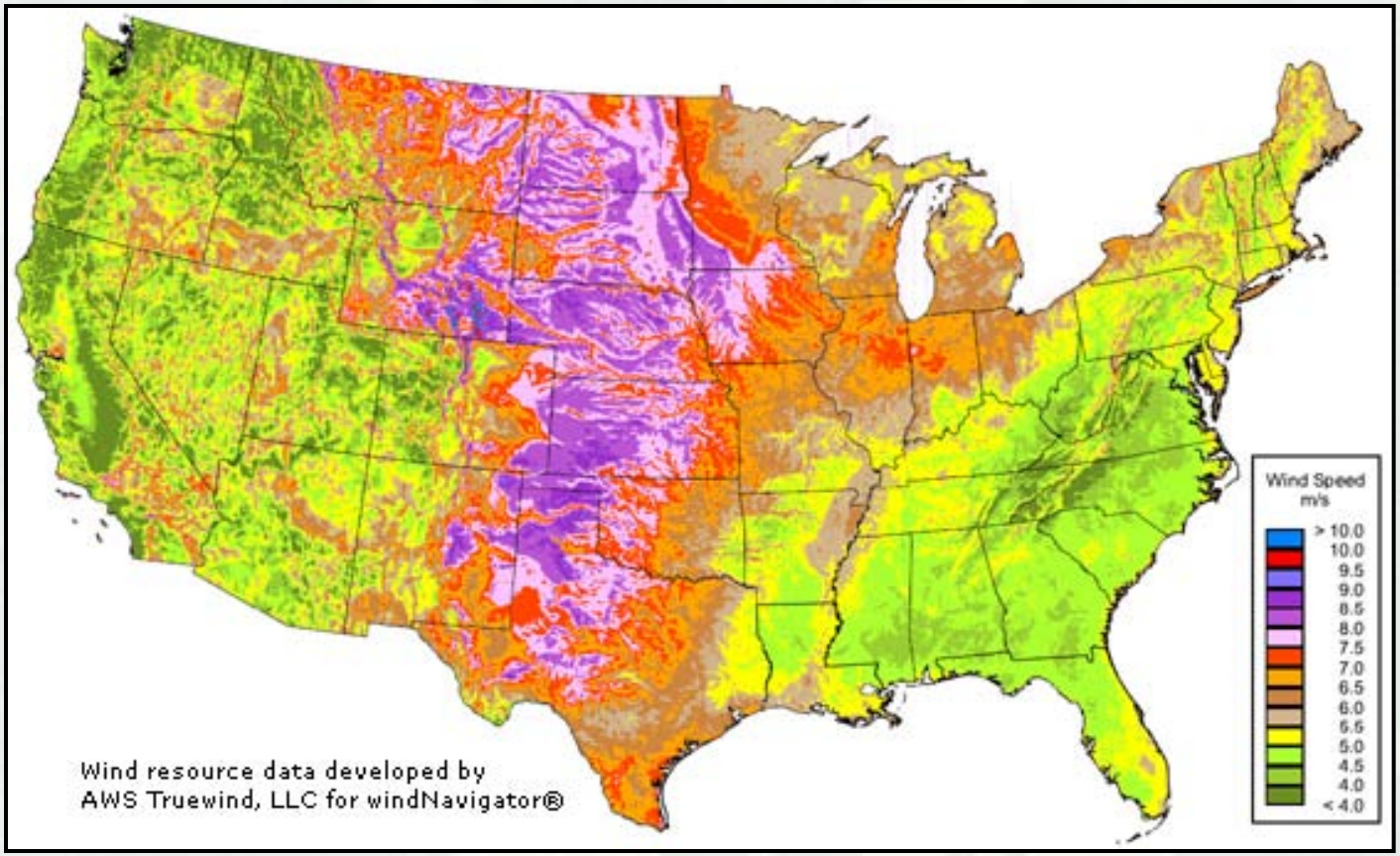
USA Population Density



Wind Projects

Cape Wind Project, 468MW (130 x 3.6MW Turbines)
Cost: $2B (~$4.25/W)
14,000 Acres
CF~25%-35%

USA Wind Resource Intensity



Problems with PV / CSP, and Wind

- Base Load Requirements
- Intermittency & Storage

	Wind	Solar	Nuclear	Natural Gas	Coal	GeoThermal
Nameplate Capacity (MW)	100	100	100	100	100	100
Acreage	3419	600	78	5	450	10K*
Construction Cost ($10^6)	$491	$1,500	$300	$161	$250	$350
Capacity Factor	30%	15%	96%	95%	74%	>95**%
Annual Generation (GW*HR)	265	130	840	830	650	790
NPV ($/KW*HR)	$0.08	$0.22	$0.07	$0.06	$0.05	$.035

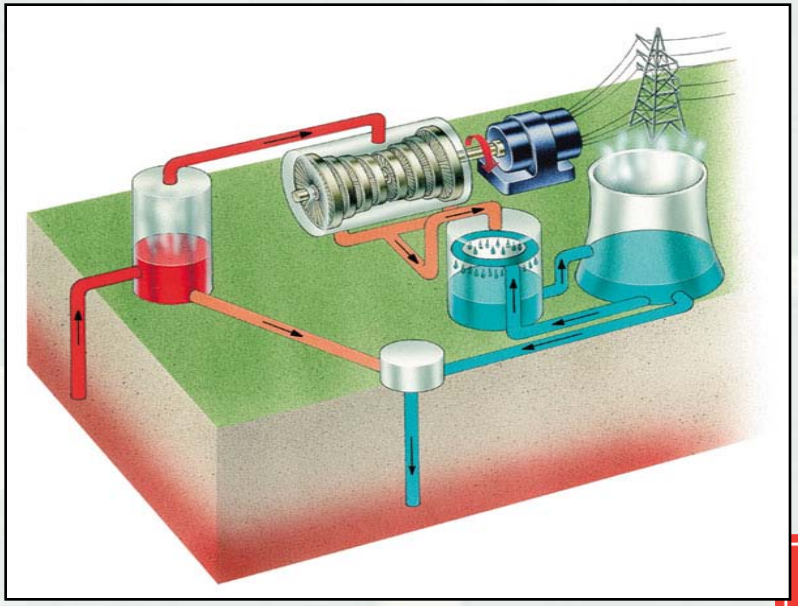
*Well field area, not surface plant size.
** Lund, Bloomquist, Boyd, and Renner, "The United States of America Country Update", World Geothermal Congress, 2005

Geothermal Projects

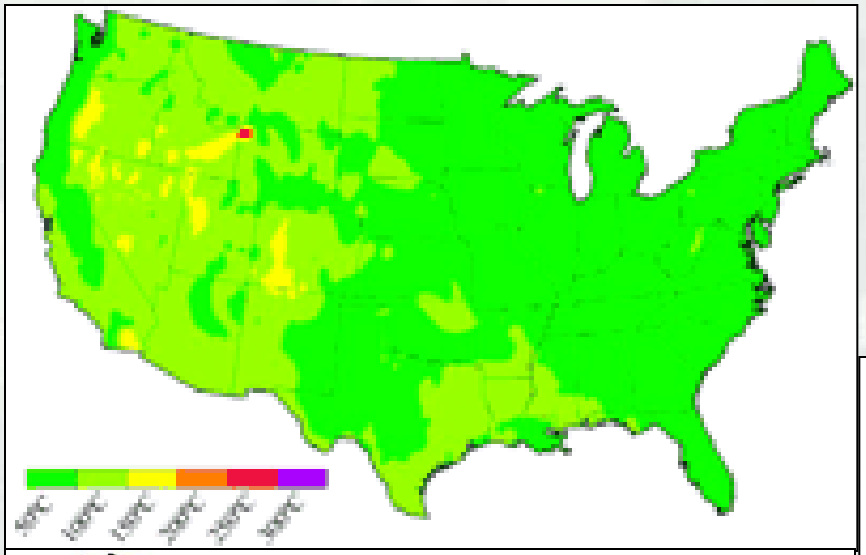
Neal Hot Springs, OR (35MW)
Cost: $105M ($3/W)
5440 Acres
CF~88%

San Emidio, NV (37MW)
Cost: $200M ($5.4/W)
CF~85%

Blue Mountain, NV(50MW)
Cost: $180M ($3.6/W)
CF~92%

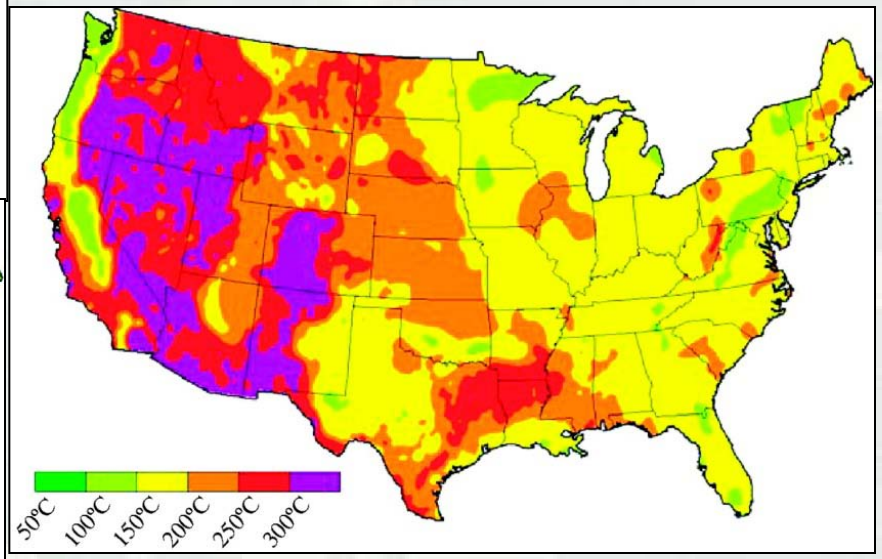


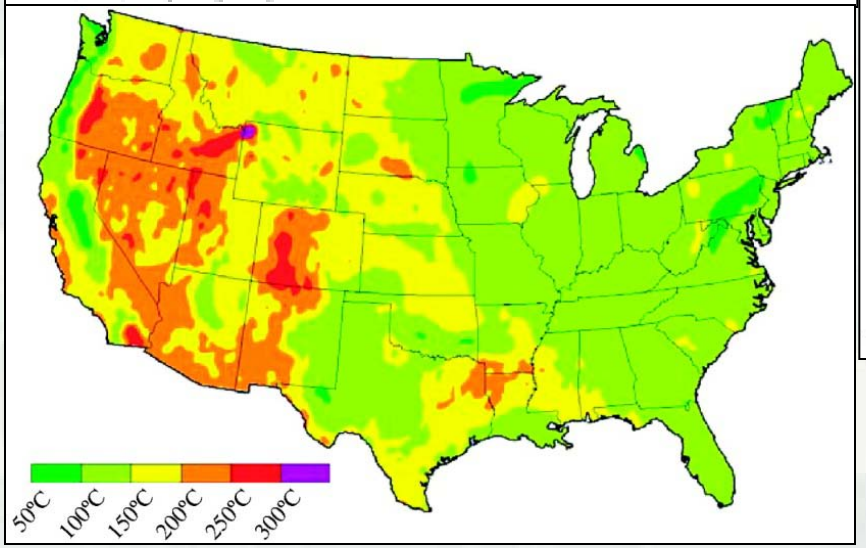
USA EGS Resource Maps



Temperatures at 3.5km

Temperatures at10km





Temperatures at 6.5km

Geothermal

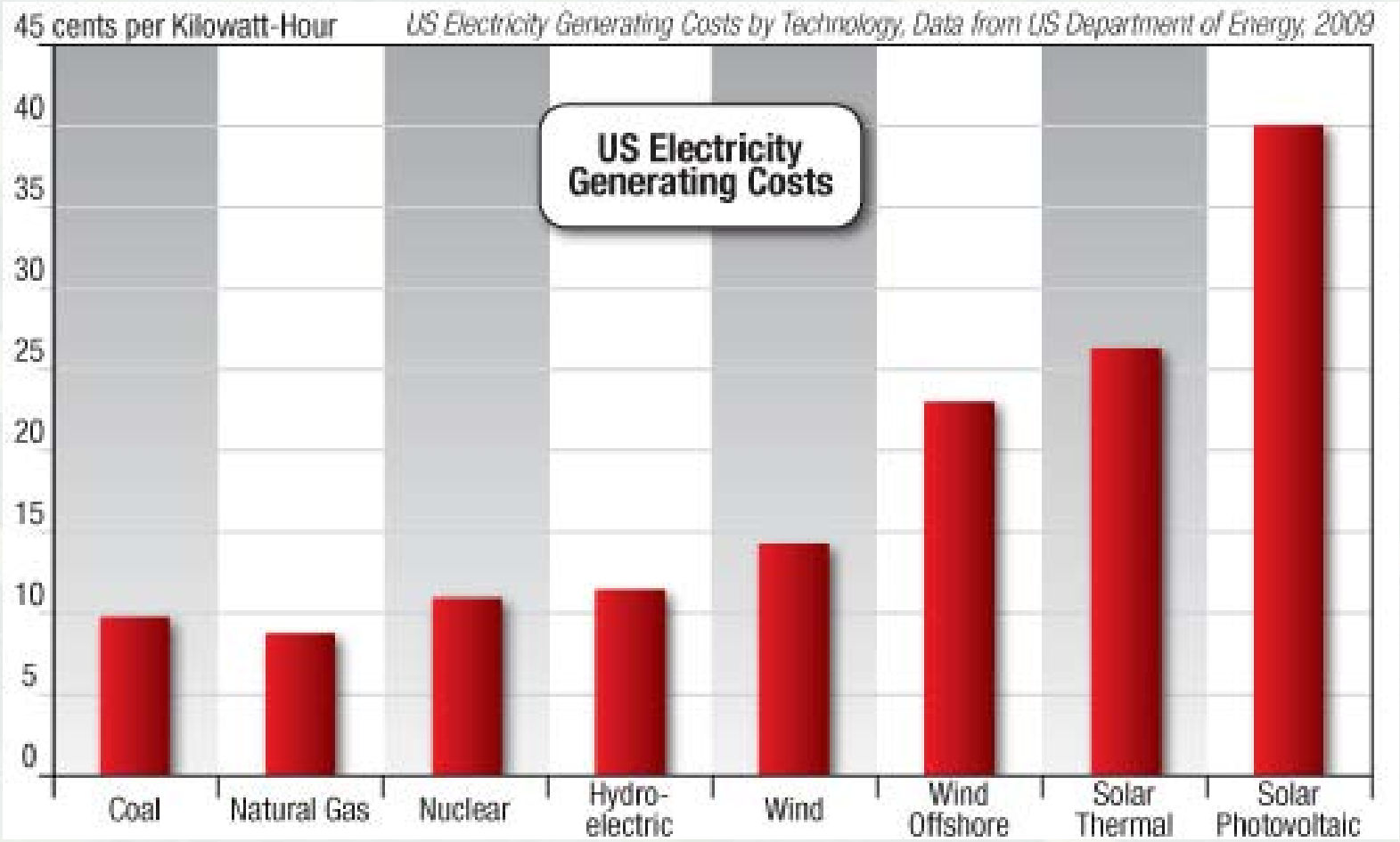
Geothermal:

1. Ubiquitous
2. Prolific
3. Credit Suisse study: better long-term pricing than coal
4. Power, Direct Heating, and Adsorption Cooling

1. Favors Western US
2. R&D still required
3. Price competition will not be realized until widely implemented

Electricity Generation $$$

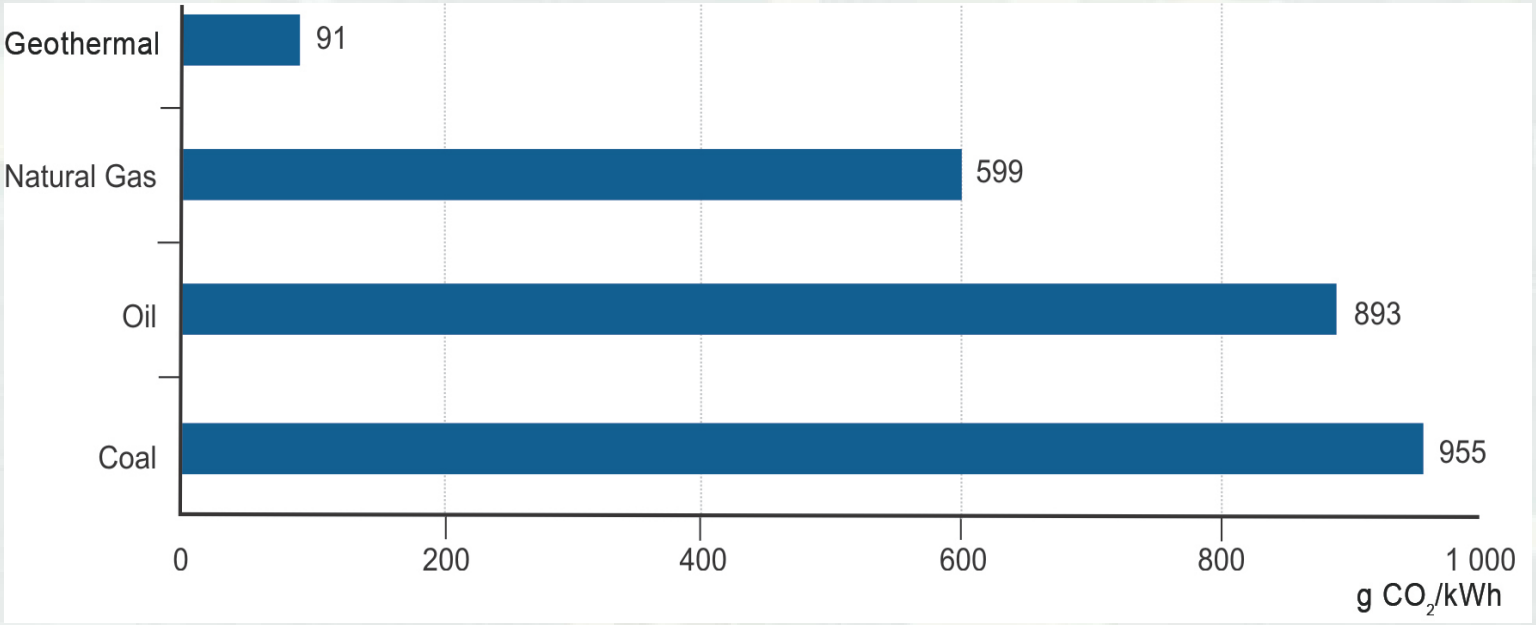
•A 2009 Credit Suisse report indicates that geothermal ($.036/kW*Hr) electricity can be had more cheaply than coal ($.055/kW*Hr) electricity can!



Electricity Generation GHG Emissions

Geothermal energy

Comparison of CO2 emissions from electricity generation

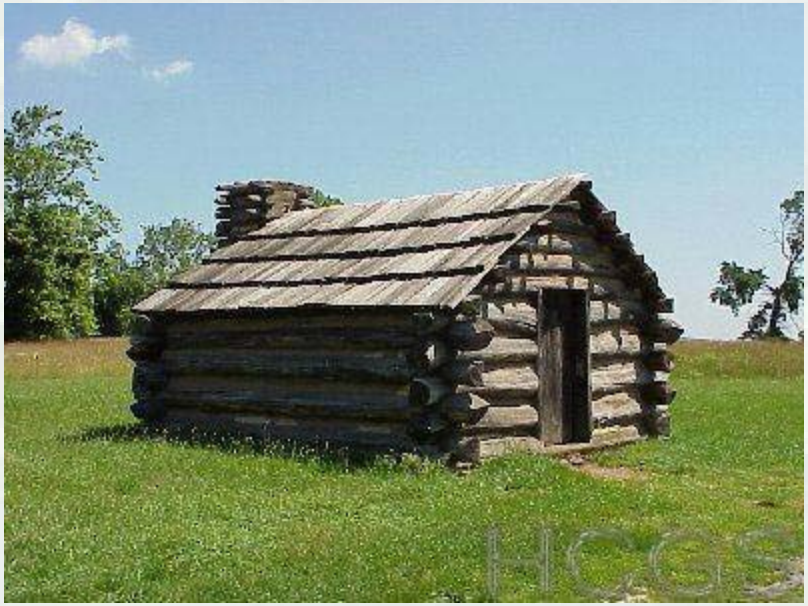


Source, World Energy Council, 2008

Renewable Power Roadmap

- Geothermal
  - Power Generation
  - Heating
  - Adsorption Cooling
- Biomass
- Solar / Wind
  - Complementary
  - Niche Applications
- Disruptive Technologies
  - Bloombox
  - JTEC
  - Chlorophyll-based Thin-Film PV Cells
  - Micro Nuclear (<300MW)

Net Zero Buildings (v1.0)



Net Zero Buildings (v2.0)

Questions and Comments

Thank you!

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